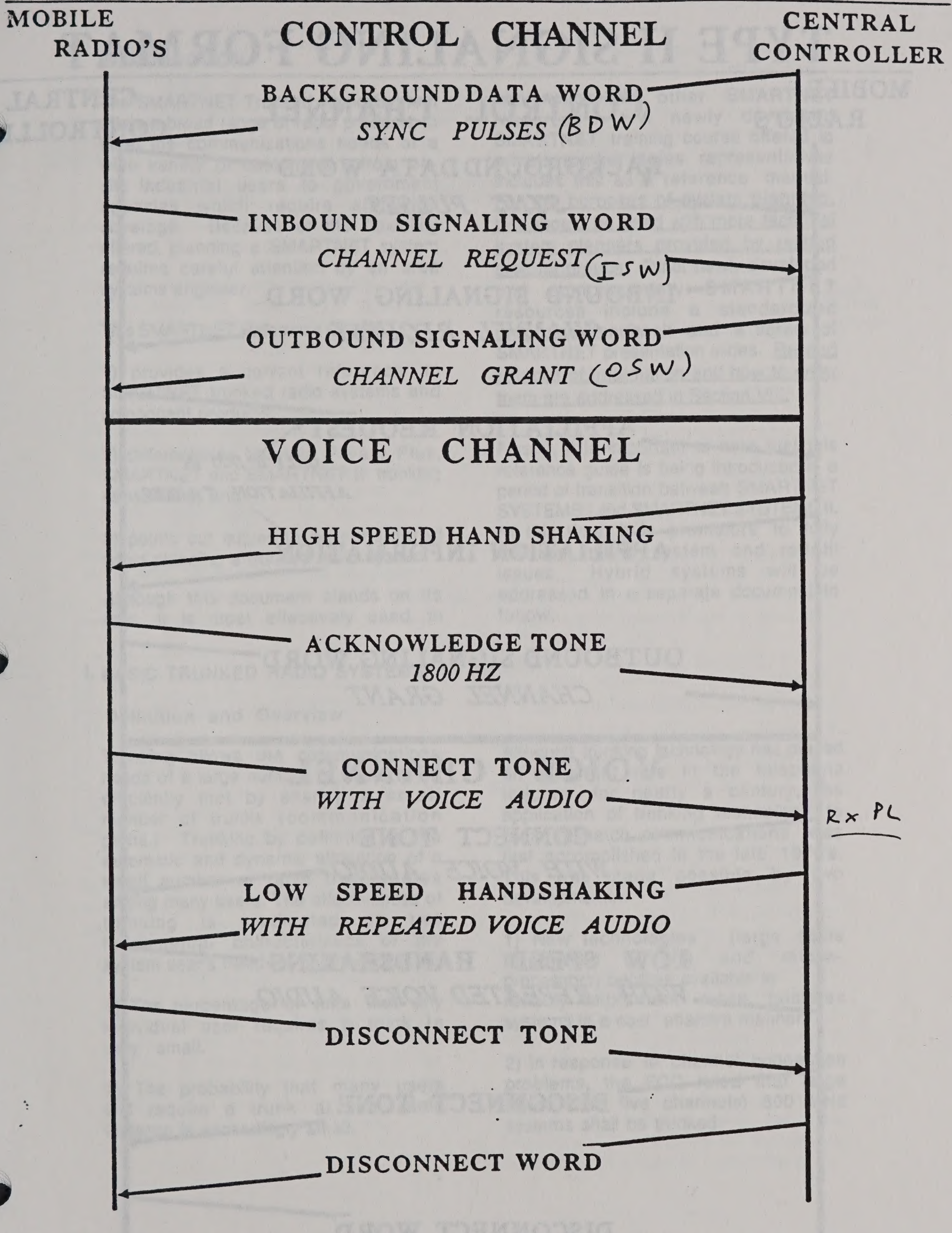
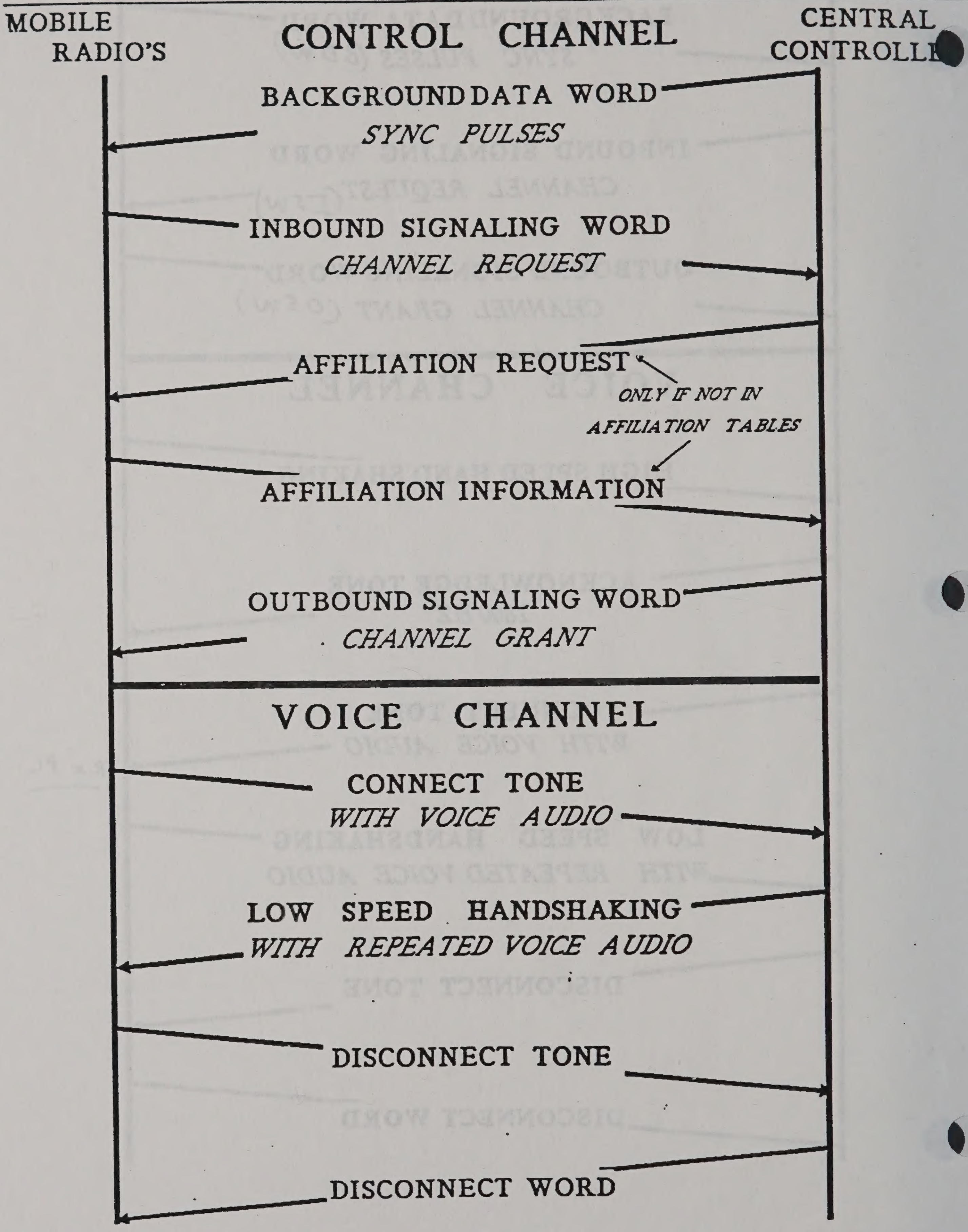
Ron Patterson

BASIC TRUNKING CONCEPTS

TYPE I SIGNALING FORMAT



TYPE II SIGNALING FORMAT



MOBILE RADIO'S

CENTRAL CONTROLLE

CONTROL CHANNEL

BACKGROUND DATA WORD
SYNC PULSES

INBOUND SIGNALING WORD
CHANNEL REQUEST

AFFILIATION REQUEST

ONLY IF NOT IN AFFILIATION TABLES

AFFILIATION INFORMATION

OUTBOUND SIGNALING WORD
CHANNEL GRANT

VOICE CHANNEL

CONNECT TONE
WITH VOICE AUDIO

LOW SPEED HANDSHAKING
WITH REPEATED VOICE AUDIO

DISCONNECT TONE

DISCONNECT WORD

INTRODUCTION

The SMARTNET Trunked Radio System offers a broad range of radio products to meet the communications needs of a wide variety of customers - from on-site industrial users to government agencies which require statewide coverage. Because of the flexibility offered, planning a SMARTNET system requires careful attention by an area systems engineer.

This SMARTNET Reference Guide:

1) provides a current reference to SMARTNET trunked radio systems and component products;

2) differentiates between Privacy Plus, SMARTNET and SMARTNET II trunking capabilities; and

3) points out issues to be considered when planning a trunked radio system.

Although this document stands on its own, it is most effectively used in conjunction with other SMARTNET resources. A newly developed SMARTNET training course offered to private market sales representatives includes this as a reference manual. For the purposes of system planning, this should be used with more technical system planners provided by related product groups. Other newly developed and complimentary SMARTNET resources include a standardized proposal handbook and a library of SMARTNET presentation slides. Related sources of information and how to order them are addressed in Section VIII.

Finally, it is important to note that this reference guide is being introduced in a period of transition between SMARTNET SYSTEMS I and SMARTNET SYSTEMS II. At this time, it is premature to fully address hybrid system and retrofit issues. Hybrid systems will be addressed in a separate document to follow.

I. BASIC TRUNKED RADIO SYSTEMS

Definition and Overview

Trunking allows the communications needs of a large number of users to be efficiently met by sharing a small number of trunks (communication paths.) Trunking by definition is the automatic and dynamic allocation of a small number of radio frequencies among many users. The effectiveness of trunking is predicated on two fundamental characteristics of the system user's need for communications:

1) The percentage of time that any individual user requires a trunk is very small.

2) The probability that many users will require a trunk at the same instance is exceedingly small.

Although trunking technology has played an important role in the telephone industry for nearly a century, the application of trunking technology to radio dispatch communications was first accomplished in the late 1970's. This was made possible by two developments:

1) New technologies (large scale integrated circuits and micro-processors) became available to reliably implement more complex systems in a cost effective manner.

2) In response to channel congestion problems, the FCC ruled that large (more than five channels) 800 MHz systems shall be trunked.

The most obvious benefit of a trunked radio system is its increased efficiency - the ability to reduce radio user waiting times. In addition, because trunking technology is computer software driven, it has opened up a number of system management capabilities to the user. In broad terms, trunking allows:

1) The organization of radio users by talkgroups rather than by frequencies;

2) The effect of a private channel per talkgroup no monitoring is necessary;

3) The flexibility to reorganize and expand the system as the need arises.

Specific features of a SMARTNET trunked radio system will be discussed in Section II.

Sequence of Operations

Motorola's basic trunked system consists of the following (Figure 1):

1.A grouping of transmitter/receiver (T/R) paired channels with one repeater per channel pair;

2. A dedicated control channel which receives radio user service requests and sends responses to service requests;

3. Multi-frequency mobiles, portables and/or control stations with microprocessor controlled logic circuitry; and

4. A system central controller which provides the intelligence to perform channel switching functions.

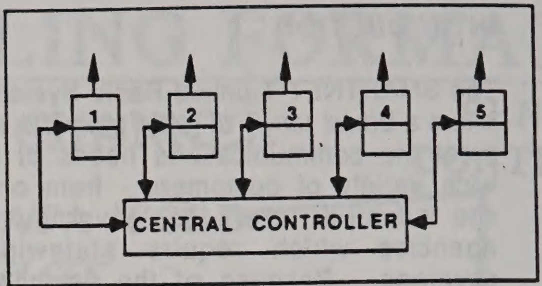


FIGURE 1

User groups access the trunked radio system via mobile, portable and/or control station radio equipment. Typical trunking communications is group oriented; one member talks while all others listen. The primary level of organization is the talk group. Figure 2 shows an example of how user talk groups can be organized on a trunked radio system. Multiple talkgroups can be organized into fleets, with a maximum of 4000 talkgroup/fleet combinations supported on a system. In this simple example, there are two talkgroups and a dispatcher position in each of three fleets shown.

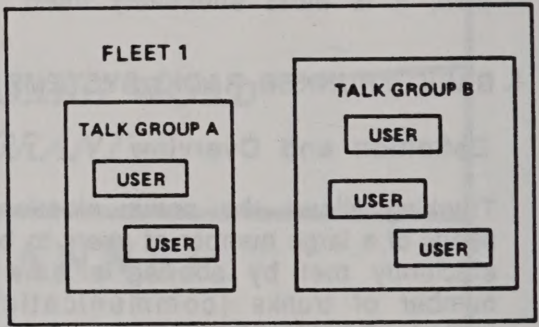


FIGURE 2

Figure 3 shows a typical 5 channel system with no communications in progress. All of the mobiles, portables, and control stations are silently monitoring the system control channel.

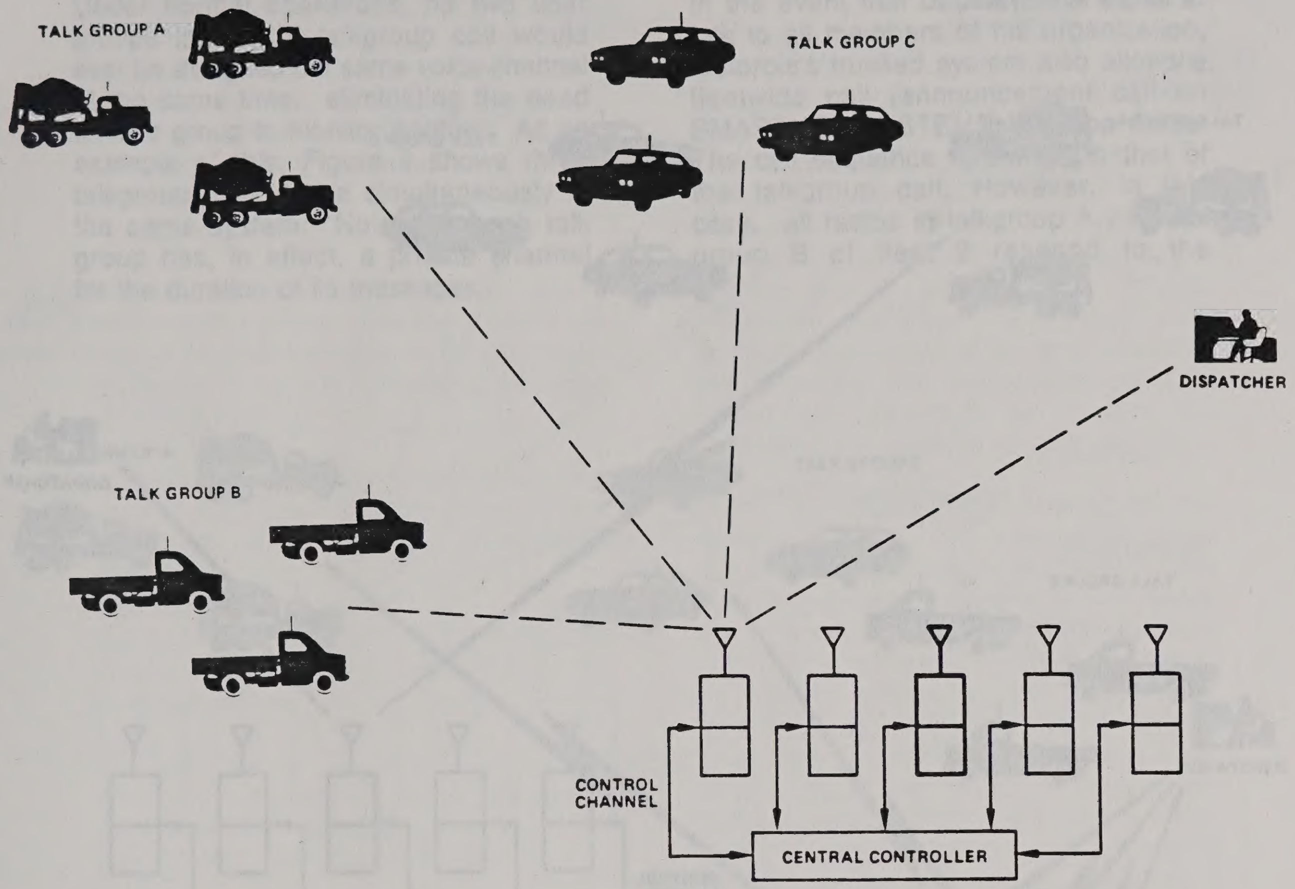


FIGURE 3 – IDLE SYSTEM

A typical call sequence proceeds as follows:

1. The dispatcher of fleet 2 wants to talk to members of talkgroup A. He depresses his push-to-talk button which automatically sends a burst of data to the central controller via the control channel. This data constitutes a request for a voice channel.

2. The system central controller reviews the status of all the voice channels and selects an unused channel, channel #2 in this case. The central controller then sends an outbound burst of data, via the control channel, directing all fleet 2, talk group A radios over to channel #2. All of the idle (not assigned to a voice channel) radio units receive the outbound instructions.

3. Only radios in talkgroup A of fleet 2 respond to the outbound instructions and automatically switch to channel #2. Radios not associated with talkgroup A will disregard the instructions and remain on the control channel. The individual who initiated the call will then have his transmitter automatically activated and will be able to communicate with other members of the talk group. Any radios in the talkgroup otherwise engaged or not turned on to the system when the talkgroup call is initiated will be signalled and automatically directed to the talkgroup call in progress once their call ends, or they turn on to the system. Figure 4 shows the end result of a talkgroup call.

The total elapsed time from press of the PTT by the initiating party until the beginning of the message is heard by the receiving talkgroup members is typically much less than 1/2 second for a single site system.

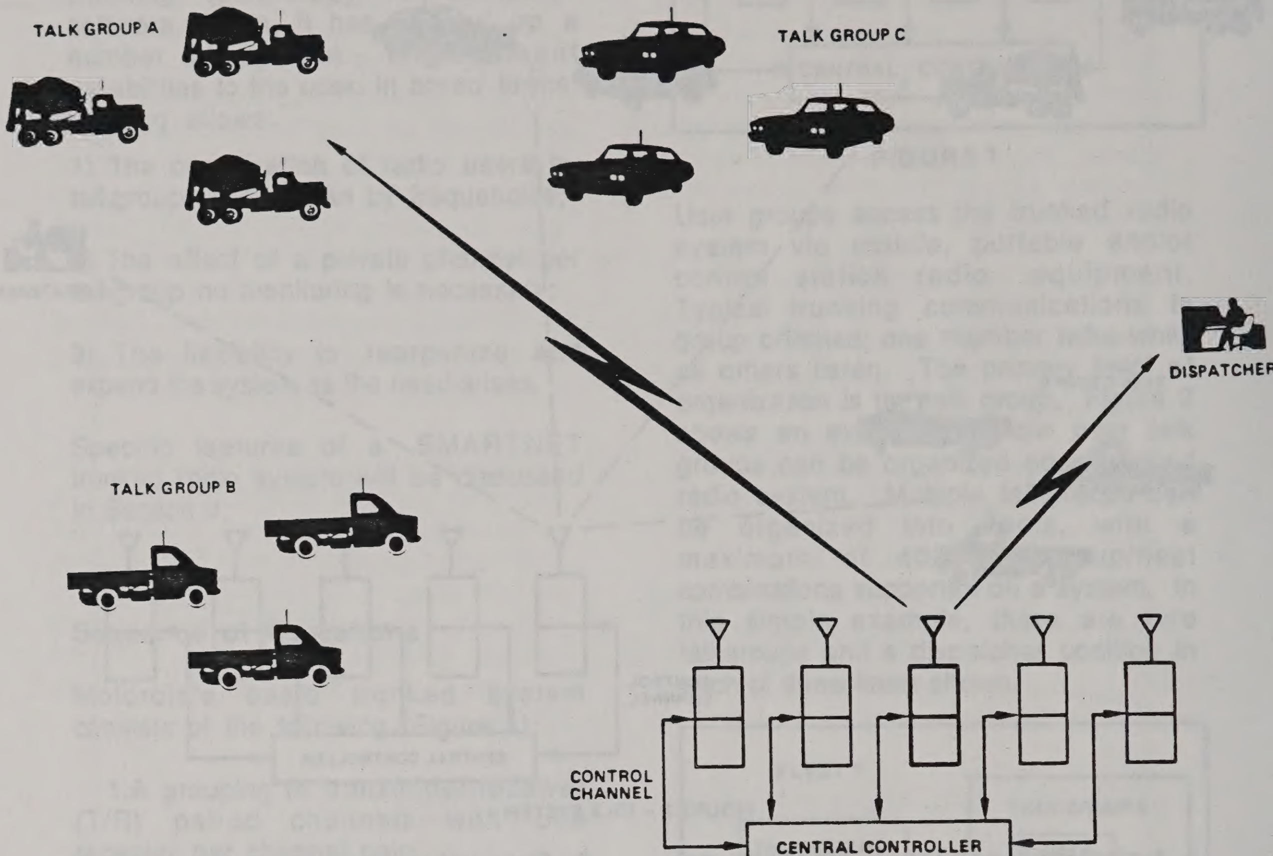


FIGURE 4 – TALK GROUP CALL

Under normal operations, no two user groups making a talkgroup call would ever be assigned the same voice channel at the same time, eliminating the need for one group to monitor another. As an example of this, Figure 5 shows three talkgroup calls active simultaneously in the same system. Note that each talk group has, in effect, a private channel for the duration of its messages.

In the event that dispatcher 2 wants to talk to all members of his organization, Motorola's trunked system also allows a fleetwide call (announcement call on SMARTNET SYSTEMS II) to be made. The call sequence is similar to that of the talkgroup call. However, in this case, all radios in talkgroup A and talk group B of fleet 2 respond to the

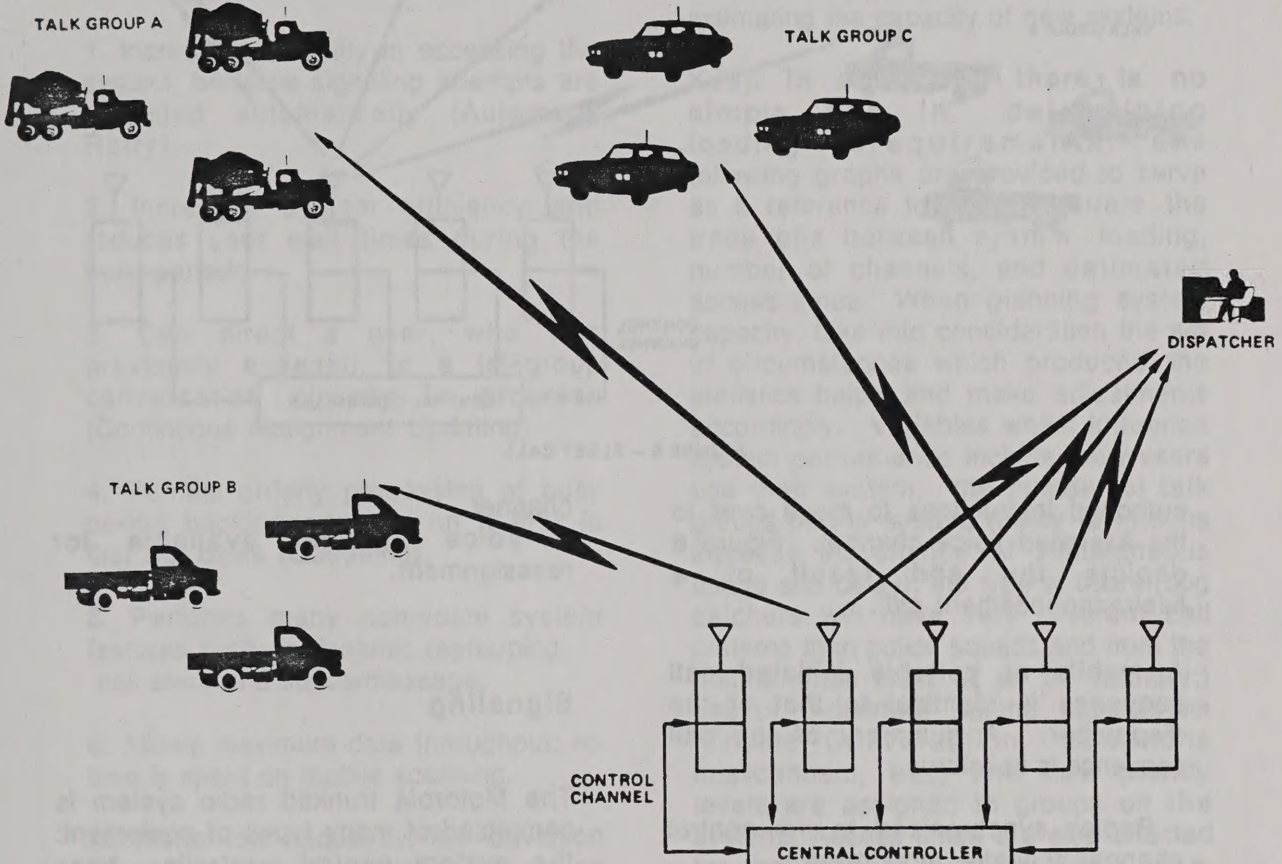


FIGURE 5 – SIMULTANEOUS TALK GROUP CALLS

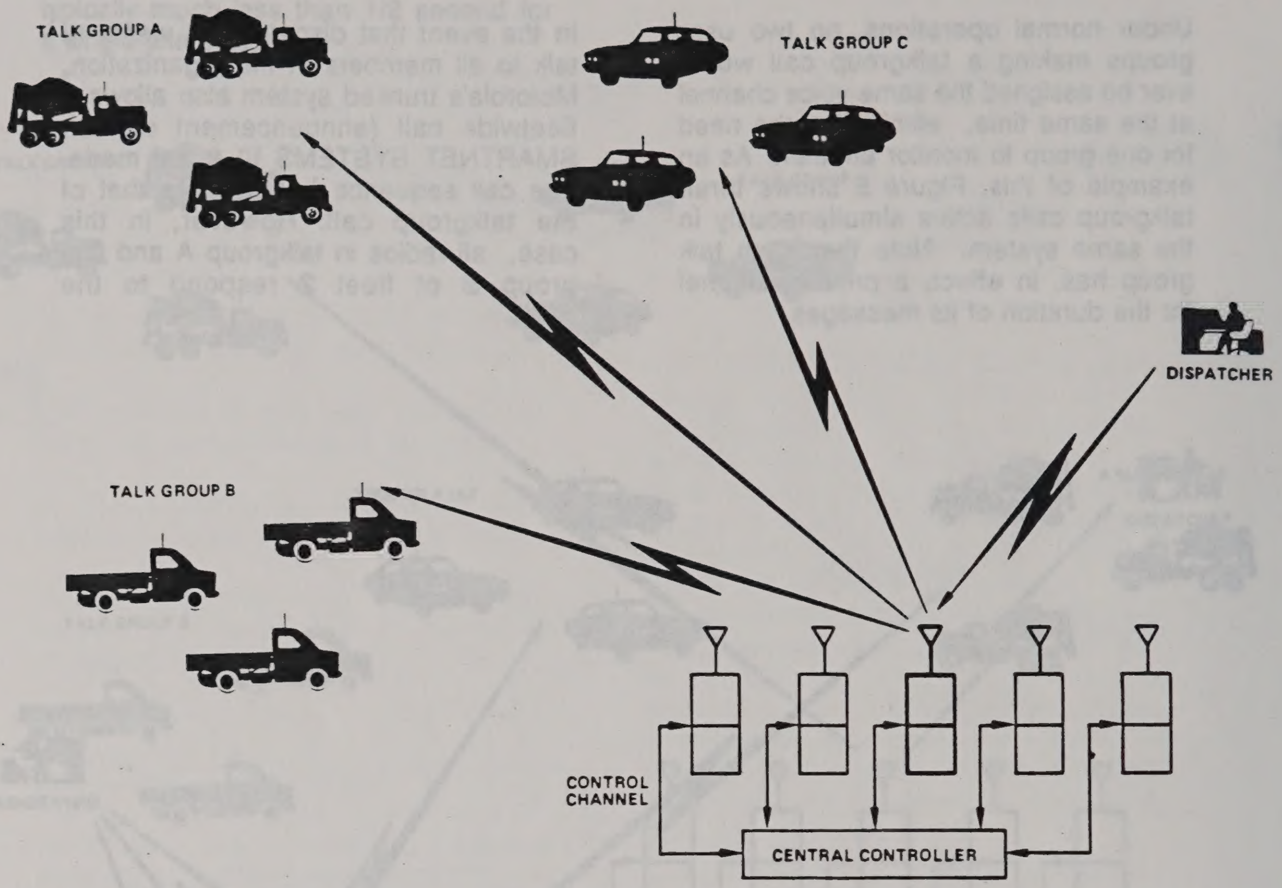


FIGURE 6 – FLEET CALL

outbound instructions to move over to the assigned voice channel. Figure 6 depicts the end result of a fleet/announcement call.

A mobile or portable initiated call sequence is identical to that of the dispatcher. A summary of the call sequence is as follows.

- Radios synchronized to the control channel (silently monitoring.)
- Initiating radio operator presses PTT.
- Inbound channel request is sent to the system central controller.
- Outbound channel assignment is broadcast to all idle radios on the system.
- All radios in the talkgroup called automatically switch to the assigned voice channel.
- Originating radio transmitter is automatically activated.
- Call messages are exchanged.
- Call is completed.
- Radios return to monitoring control channel.
- Voice channel available for reassignment.

Signaling

The Motorola trunked radio system is comprised of many types of equipment: the system central controller, base station repeaters, mobile and portable radios, and control stations. A data communications network ties these entities together to achieve efficient systems operation.

Most data signaling takes place over the control channel. Requests for service are sent from system users to the system central controller over the control channel. Similarly, channel assignments and commands from the central are sent to individual radio units over the control channel. The information necessary to address radios and to specify action to be taken is sent in 23 millisecond packets. Information is assembled into a sophisticated coding format, with sufficient error detection and correction capabilities to assure system reliability. Encoded data is sent at 3600 baud by direct frequency modulation.

Not all trunked radio systems use a dedicated control channel which is always available to receive data packets. However, there are several advantages of having one; it:

1. Increases reliability in accessing the system, because signaling attempts are repeated automatically (Automatic Retry).

2. Increases system efficiency and reduces user wait times during the busy periods.

3. Can direct a user, who was previously engaged, to a talkgroup conversation already in progress (Continuous Assignment Updating).

4. Permits orderly processing of busy period backlogged calls on a first in first out basis (Queueing).

5. Performs many non-voice system features such as dynamic regrouping, call alert, and status/message.

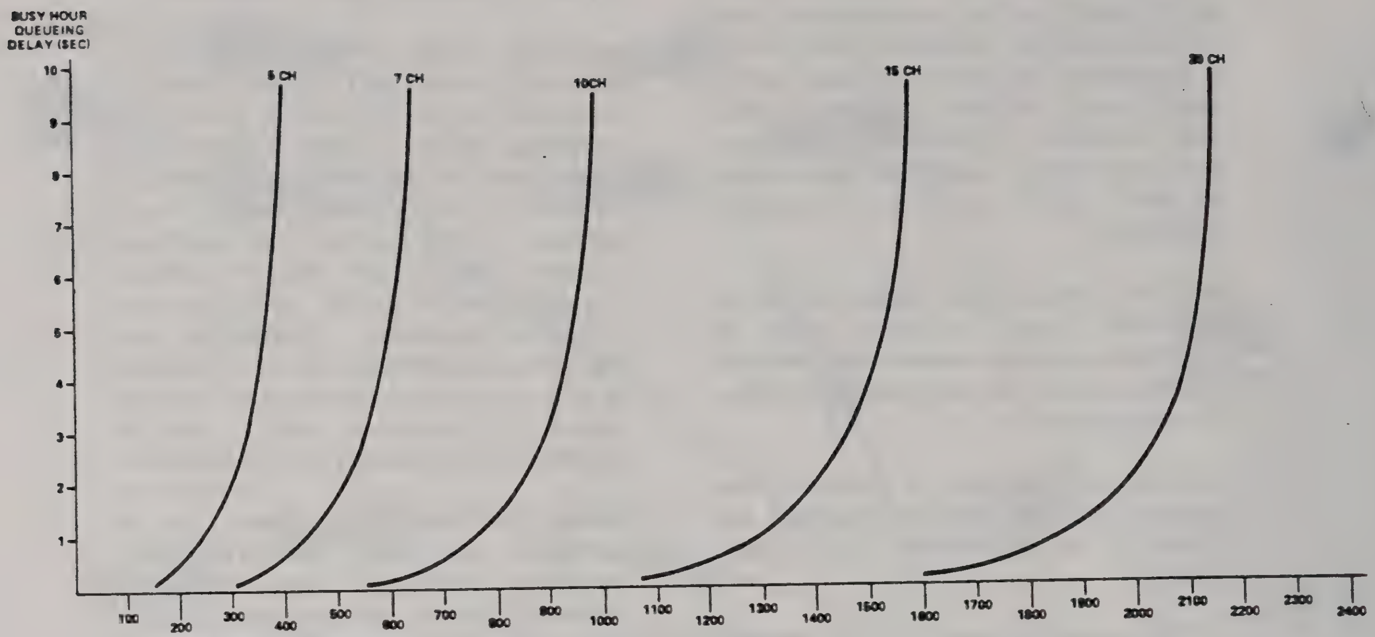
6. Allows maximum data throughput; no time is spent on mobile scanning.

Additional low frequency, low deviation signaling occurs over the voice channels. Continuous tone, subaudible signals are transmitted by mobiles and portables, and digital subaudible signals are transmitted from base to mobile. These signals are necessary to provide misdirected radio protection, priority monitor and call update information.

System Capacity and Response

Although busy periods are of short duration, SMARTNET systems must be designed to accommodate peak hour message traffic. System performance characteristics are therefore stated in relation to busy hour (worst case) periods. This section will address system capacity and performance on typical public safety and private industrial systems. Statistical data derived by monitoring air time usage of public safety and commercial system users is provided as a tool for estimating the capacity of new systems.

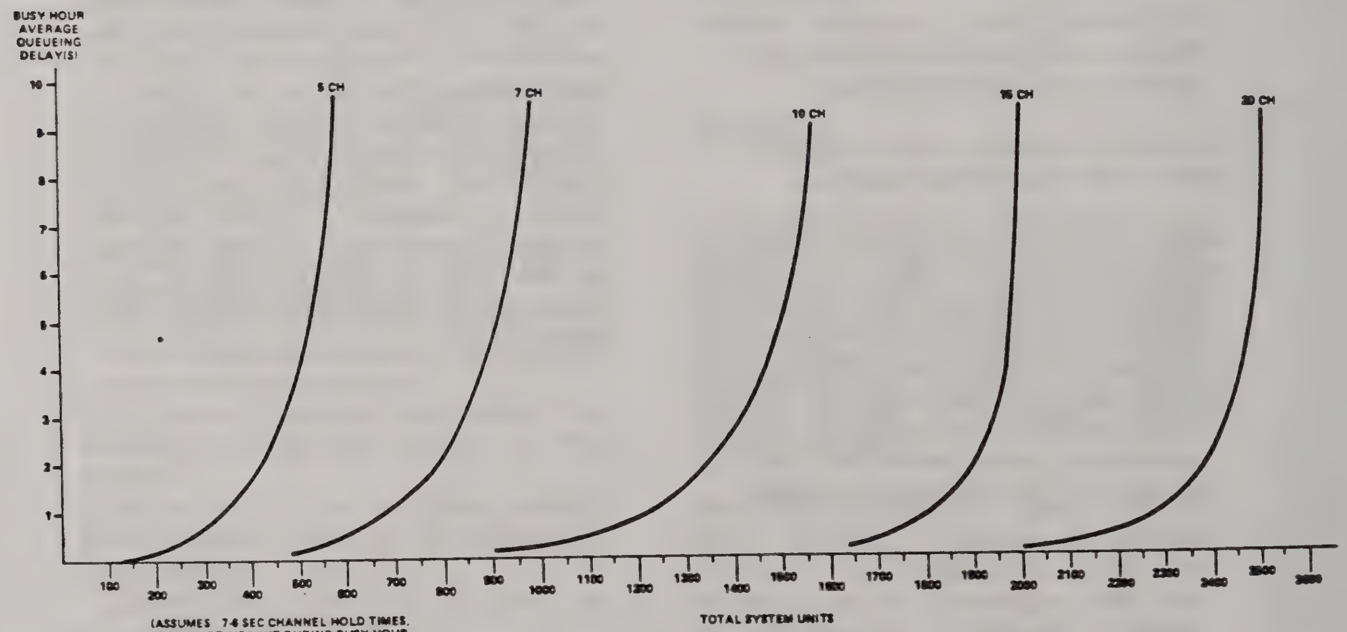
Keep in mind that there is no simple rule in determining loading rerequirements. The following graphs are provided to serve as a reference tool and illustrate the trade offs between system loading, number of channels, and estimated access times. When planning system capacity, take into consideration the set of circumstances which produced the statistics below and make adjustments accordingly. Variables which influence system performance include: how users use their system, the number of talk groups on the system (many talkgroups increase the chance of simultaneous usage and delay); the type of users (dog catchers will have very different call patterns than police squads and from the maintenance crew at an oil refinery;) use of individual calling capabilities (Private Conversation, telephone interconnect, etc;) and how priority levels are assigned to groups on the system. Access times are also affected by the type of system; single site, Simulcast or Automatic Multiple Site Select.



(ASSUMES: 10 SEC CALLS, 3 CALLS/UNIT)

FIGURE 7 - PUBLIC SAFETY LOADING EXAMPLE

Figure 7 shows system access delays in relation to total active radios loaded for a 5 to 20 channel public safety system. System access time includes time elapsed between the instant the radio operator presses his PTT and completion of the channel assignment. Access times could be lengthened by inbound or outbound signaling delays or any voice channel blocking. The public safety loading statistics represent a system with: more talkgroups than channels (approximately three times as many,) equal priority for all users, minimal individual calling, an average of 10 second call lengths, and 3 calls per unit (typical of police operations) during the busy hour.



(ASSUMES 7-8 SEC CHANNEL HOLD TIMES,
18 SEC AIRTIME/UNIT DURING BUSY HOUR
1 SEC RPTR DROPOUT)

FIGURE 8 - SMR TYPE LOADING EXAMPLE

TABLE 1 Typical Access Times by System Type (Milliseconds)

	Enhanced Protocol I	Enhanced Protocol II
Single Site	450	260
Single Site with Console	550	275
Simulcast/Spectra Tac	880	360
AMSS	950	420

System usage levels on most industrial systems fall between those on public safety and commercial systems, with public safety being the worst case and commercial SMRs the best. Figure 8 illustrates the relationship between access delays and total radios programmed on a 5-20 channel SMR. SMR loading statistics assume equal priority for all users, 18 second call lengths, 7.6 second hold times, and 1 message per unit per hour.

Although system loading is planned with the worst case in mind, access times are typically far faster during normal (non-busy) operation as noted in Table 1.

Fleetmapping

The fleetmapping process presents alternatives for configuring talkgroups on a trunked radio system. The fleetmap is the software "code" stored in the central controller memory which holds the talkgroup (fleet and talkgroup in SMARTNET I) and individual identities (personalities) of each radio on the system.

In Type I systems (SMARTNET I and 800 MHz Privacy Plus systems,) there are trade-offs between the number of talkgroups and individual IDs which can be supported as represented by a fleet size code. (Fleet refers to a grouping of radio IDs. How talkgroups are grouped into fleets will affect the operation of certain features.) With Type II systems, (SMARTNET SYSTEMS II and 900 MHz Privacy Plus,) fleet boundaries are not necessary and there are no restrictions on talkgroup and individual ID combinations up to a limit of 48,000 total IDs and 4000 talkgroups total per system.

In either case, there will be a trade-off between the number of talkgroups and the efficiency of channel usage. A greater number of talkgroups may result in greater utilization of channel resources. In addition, in dispatch oriented applications (e.g. public safety,) the number of talkgroups formed should not exceed the capabilities of the dispatchers. Typically, one dispatcher can handle up to 8 talkgroups.

Regardless of the type of system, the fleetmapping process begins with identifying:

1. Who needs to talk to whom on the system and how individuals should be grouped into talkgroups, and
2. Expansion needs; how many radios will be added to the system.

With Type II systems, once these groups and any special groups such as announcement call groups are set up, you are essentially done. On Type I systems, the fleetmap has greater restrictions and therefore requires attention to the following:

*The total number of separate talk groups and radios per fleet including mobiles, portables, console positions, SIMS, Intrac, etc. (plus expansion.)

- How users intend to use their radios or optionability of the radios.
- How many dynamic regrouping fleets and identities need to be set aside.

With this information the appropriate fleet size codes can be selected from Table 2. Each SMARTNET I system can accommodate any combination of size codes up to a total of eight block points. (800 MHz Privacy Plus systems are restricted to size codes A-D.) For example, 2 Type B size codes use 2 points and 1 Type M uses 2 more points. The addition of an O size code requires 4 more block points, thus using up the remainder of block points and filling the (Type 1) fleet map.

TABLE 2 TYPE I FLEET MAP COMPONENTS

Fleet Block Type (Size Code)	Block Points Per System	# of Fleets In Block	Max ID's Per Fleet	Subfleets Per Fleet	Total ID's In Block	Total Subfleets In Block
A	1	128	16	3	2048	324
B	1	16	64	7	1024	112
C	1	8	128	7	1024	56
D	1	1	512	15	512	15
E	1	64	32	3	2048	192
F	1	32	32	7	1024	224
G	1	32	64	3	2048	96
H	1	16	128	3	2048	48
I	1	8	256	3	2048	24
J	1	4	256	7	1024	28
K	1	2	256	15	512	30
M	2	1	1024	15	1024	15
O	4	1	2048	15	2048	15
Q	8	1	4096	15	4096	15

- System "Block Point Budget" is 8
- Max ID's = 16,384/System
- Max Sublfeets = 3072/System

TRUNKING BENEFITS & FEATURES

There are many benefits and features offered in a Motorola trunked radio system. This section provides a functional description of each feature and differentiates between basic trunking features, inherent in all Motorola trunked systems) and advanced SMARTNET features, offered only in SMARTNET and SMARTNET SYSTEMSII). See Table 3, Features-Systems Matrix for a summary of which features are available on which systems.

There are several conveniences built into a trunked radio system which are not available on conventional systems. The following features simplify radio operations for the user and are inherent to various degrees in all Motorola trunked systems.

- Busy Queuing and Callback

Although trunked systems are considerably more efficient than conventional systems, there may still be times when all of the voice channels are busy or when channels with special call processing capabilities (e.g.. telephone interconnect) are busy. If a radio user depresses the PTT while all the system channels are in use, he will hear a series of (busy) tones until a channel is assigned or he releases the PTT. (A continuous tone will be heard when the PTT is depressed and the radio is out of range or the system is out of service.)

For convenience, any users requesting system access during a busy period will be put in a queue. On a FIFO (first in first out) basis, when a channel does become available, the system central controller will notify the first mobile by "calling him back". A talk permit tone heard on the operator's radio alerts him of the call back. This feature allows the radio user to put the microphone down in a busy situation and wait for the callback, instead of continually keying in an effort to gain channel access.

- Multiple Priority Levels

In addition to giving priority to recent users, Motorola trunked systems provide multiple levels of priority to allow system access to the most critical users during busy periods. Users and groups may be assigned a particular priority level and in the event of a busy, channel requests are processed according to priority on a first come first served basis. Assignment of priority levels can be controlled by the system manager via a System Manager Terminal or through SIMS (with the proper software option.) One level of priority (tactical) can be assigned to a talk group via the Centracom Series II console.

Three levels of priority are available on a Privacy Plus system; 5 levels on a SMARTNET system; and 8 or more levels on SMARTNET SYSTEM II. An emergency call (described later) will always take the highest priority on a SMARTNET system (I or II.)

- Automatic Retry

Automatic Retry is a feature built into Motorola trunked systems to ensure system access and eliminate the need for a radio user to rekey or remain keyed in an effort to gain a channel. When the radio operator pushes his PTT, the radio sends a burst of data to the system central controller via the system control channel to request a voice channel. To ensure that the request gets through in the event of weak signal levels or interference, the radio unit will automatically continue to send a channel request until the request is acknowledged by the central controller, or until approximately 4 seconds have passed. Usually, because of effective

TRUNKING FEATURES BY SYSTEM

		PRIVACY PLUS (800 MHz)	PRIVACY PLUS (900 MHz)	SMARTNET (800 MHz)	SMARTNET II (800 & 900 MH
1	CONVENIENCE/EASE OF USE				
2	FAST ACCESS (SINGLE SITE)	<500 MS	<300 MS	<500 MS*	<300 MS
3	NO MONITORING REQUIRED	X	X	X	X
4	BUSY QUEUING & CALLBACK	X	X	X	X
5	PRIORITY LEVELS	UP TO 3	UP TO 3	UP TO 5	8 OR MORE
6	AUTOMATIC RETRY	X	X	X	X
7	RECENT USER PRIORITY	X	X	X	X
8	DISPLAYS	X (BY RADIO)	X (BY RADIO)	X (BY RADIO)	X (BY RADIO)
9	INDICATOR TONES	X	X	X	X
10	OPERATIONAL FLEXIBILITY				
11	SUBFLEET CALLS	X	X	X	X
12	FLEET CALLS	X	X	X	
13	MULTI GROUP ANNOUNCEMENT				X
14	DUAL MODE OPERATION	X (BY RADIO)	X (BY RADIO)	X (BY RADIO)	X (BY RADIO)
15	REPEATER TALKAROUND	X (BY RADIO)	X (BY RADIO)	X (BY RADIO)	X (BY RADIO)
16	SUBFLEET MERGE			X	X
17	ROAMING (SYSTEM TO SYSTEM)	X (BY RADIO)	X (BY RADIO)	X (BY RADIO)	X (BY RADIO)
18	SYSTEM DESIGN FLEXIBILITY				
19	TALKGROUP PARTITIONING	X	X	X	X
20	3 TO 20 CHANNELS	X	X	X	X
21	FLEETMAPPING	A,B,C,D, FLEETS	4000 TLKGRPS	A-O FLEETS	4000 TLKGRPS
22	FIELD PROGRAMMING	X (BY RADIO)	X (BY RADIO)	X (BY RADIO)	X (BY RADIO)
23	EMERGENCY RESPONSE				
24	EMERGENCY ALARM/CALL			X	X
25	SELECTIVE CALLING				
26	CALL ALERT	CA I	CA II	CA I	CA II
27	PRIVATE CONVERSATION	PC I & II	PC II	PC I & II	PC II
28	UNIVERSAL ID		X	X	X

* <300 MS OPTIONAL

TRUNKING FEATURES BY SYSTEM

		PRIVACY PLUS (800 MHz)	PRIVACY PLUS (900 MHz)	SMARTNET (800 MHz)	SMARTNET II (800 & 900 MHz)
29	MONITORING				
30	TRUNKED SYSTEM SCAN	X	X		
31	TRUNKED TALKGROUP SCAN			X	X
32	PRIORITY MONITOR				
33	PERSONALITY SLAVED			X	X
34	OPERATOR SELECTABLE			X (BY RADIO)	X (BY RADIO)
35	TELEPHONE CALLS				
36	MOBILE TO LAND	X	X	X	X
37	LAND TO MOBILE	X	X	X	X
38	LAND TO SUBFLEET	X	X	X	X
39	INTEROPERABILITY (SIS I)				
40	CONSOLE PATCH			X	X
41	MULTI SYSTEM ACCESS	X	X	X	X
42	INTERCONNECT	X	X	X	X
43	SYSTEM MANAGEMENT/CONTROL				
44	SELECTIVE RADIO INHIBIT			X	X
45	DYNAMIC REGROUPING			X	X
46	STORM PLANS			X	X
47	STATUS MESSAGE	X		X	X
48	SYSTEM/MANAGER	X	X	X	X
49	PTT ID DISPLAY			X	X
50	PRIORITY LEVEL CONTROL	X	X	X	X
51	DATA LOGGING	X	X	X	X
52	UNIT REGISTRATION				X
53	COMMAND & CONTROL INTERFACE			X	X

TRUNKING FEATURES BY SYSTEM

		PRIVACY PLUS (800 MHz)	PRIVACY PLUS (900 MHz)	SMARTNET (800 MHz)	SMARTNET II (800 & 900 MHz)
54	RELIABILITY				
55	MULTIPLE CHANNELS	X	X	X	X
56	BACK UP CONTROL CHANNELS	X	X	X	X
57	REDUNDANT CENTRAL			X	X
58	FAILSOFT	X	X	X	X
59	SMR BACKUP			X	X
60	SELF DIAGNOSTICS	X	X	X	X
61	RECEIVER INTERFERENCE SHUTDOWN	X	X	X	X
62	TRANSMITTER POWER SHUTDOWN	X	X	X	X
63	MISDIRECTED RADIO PROTECTION	X	X	X	X
64	CONTINUOUS CHANNEL UPDATE	X	X	X	X
65	WIDE AREA COVERAGE				
66	SIMULCAST			X	X
67	AMSS			X	X
68	SPECTRA-TAC/DIGITAC VOTING			X	X
69	SYS TO SYS INTERCONNECT	X	X	X	X
70	SYSTEM SEARCH & LOCK			X	X
71	SUB SYSTEM INTEGRATION				
72	TONE & VOICE PAGING	X	X	X	X
73	TRACKNET AVL	X	X	X	X
74	INTRAC ALARM & CONTROL	X	X	X	X
75	TEXT DATA	X	X	X	X
76	SECURENET			X	X (800 MHz ONLY)
77	CALL BOXES			X	X

system throughput, the acknowledgement takes place on the first try. Automatic retrys are random to minimize the possibility of contention on the control channel..

- Recent User Priority

To ensure uninterrupted communications, recent user priority has been designed into Motorola trunked systems. This assures that users who have previously been assigned a voice channel will receive priority over other system users of the same priority. Recent user status ends if a PTT is not activated within 10 seconds of the channel assignment ending.

- Ergonomics

Trunked radios have been designed to be user friendly. Depending on the trunked radio model various display options, keypad controls and indicator tones are provided to make the radio easy to use.

Calling/Operating Capabilities

SMARTNET trunked radio systems offer the radio user a variety of calling capabilities to suit a variety of communications needs. The following types of calls are available as features or options on the radios and/or console.

- Talkgroup Call

The talkgroup is the primary level of organization for communications on a trunked radio system. Radios assigned to a given talkgroup will be provided with "talkgroup call" and will under normal operation, only be able to communicate with other members of the same talkgroup. This provides the effect of a private channel down to the talkgroup level.

The capability of allowing radio users of the same fleet to selectively move between talkgroups of that fleet is optionally provided on the radio unit with a manual switch or keyboard. A SMARTNET system supervisor can also change a radio user's talkgroup assignment via the dynamic regrouping option available on SMARTNET trunking terminals.

- Fleet Call

Fleet calls can be made on both Privacy Plus and SMARTNET 800 MHz systems. It allows simultaneous communications to all members of the talkgroups of a fleet, utilizing a single channel resource. Fleet calls can only be made from a radio unit with the capability programmed into its code plug and which is enabled in the central controller database.

Fleet calling capability should be assigned with care because of the air time it requires to set up this kind of call. When a fleet call is placed, the user must wait for others in his fleet engaged in conversation to dekey their mics before the fleet call can begin. Others in the fleet will get a busy signal if they try to make a call after a fleet call has been initiated but has not yet been granted a channel. Calls initiated during this period will not be placed in a queue and must be reinitiated after the fleet call. Those involved in telephone interconnect calls are not affected by a fleet call. Once they complete their telephone call, they will automatically join the fleet call in progress.

A fleet call is transmission trunked (described in System Design Flexibility). Other radios in the fleet will not be able to transmit until the fleet call ends. After the fleetwide announcement has been made and the user dekeys, the fleet will return to normal dispatch calling operation.

- Multi-Group Announcement

Multi-group announcement is the feature used to make a multi-group call on SMARTNET SYSTEMS II. This feature can be optioned to operate similarly to a fleet call (the caller must wait for other members of the fleet to dekey before he can transmit,) or with an interrupt capability. With interrupt, when a user initiates a multi-group call, his call will immediately interrupt other conversations in progress without waiting for other users to dekey. However, those radio users who are transmitting on a voice channel will not hear the announcement call until they dekey. They will then join the announcement call if it is still in progress. Everyone in a multi-group announcement will have talk back capabilities. The multi-group announcement is message trunked (described in System Design Flexibility).

- System Call

A system wide call operates similarly to a fleet call and has similar ramifications in regards to air time usage. System calls can only be placed from a Centracom Series II console or a Syntor SP05 consolette which has been programmed and enabled on the central controller database to do so. When a system call has been placed, the user must wait for all users on the system to dekey and join the system call. All other users will get a busy if they try to make a call during this period. These call attempts will not be queued and must be reinitiated after the system call is completed. Users engaged in telephone interconnect calls will not be aware of the system call until their phone call is completed, at which time they will join the system call in progress. The system call is transmission trunked. After the system wide announcement is completed and the user dekeys, the system will return to normal dispatch operations.

- Dual Mode Operation

Dual mode capability is a standard feature of most SMARTNET radios (e.g. except SMARTNET 1000 and MTX 800.) Conventional repeaters are often designed into a trunked system to extend coverage to fringe areas. In order for a user to communicate in the conventional mode, his radio unit must be programmed with a conventional frequency. SMARTNET radios are equipped with a "smart" PTT. While in the conventional mode, if the channel is busy when the radio user presses his PTT, the radio will not transmit but will monitor the channel. To transmit the user must press the PTT a second time.

- Repeater Talkaround

Repeater talkaround gives a radio user the capability to talk "radio to radio" when out of range of the trunked radio infrastructure, or when there is a special need to directly talk "radio to radio", e.g. telephone company cable pullers. Talkaround is an option programmed into the radio. It utilizes a conventional channel that is not a part of the trunked system.

To achieve talkaround, the radio user who wishes to initiate a call switches his radio over to the talkaround mode. At this time, his radio can transmit on the same frequency at which the radio he is calling receives messages, and therefore bypasses the trunked system. The user called must be instructed, or by a pre-established procedure, must also switch over to the talkaround mode in order to respond to the call.

- Talkgroup Merge

Talkgroup merge is a dispatch function in SMARTNET systems which allows multiple talkgroups to be merged together to talk on one voice channel. It is a function that only a trunked console can carry out and is a standard feature of Centracom II consoles. Efficiency is a major benefit of this feature since only one channel is used. Also, once it is set up, merging occurs very quickly.

Two types of talkgroup merge are available, multi-select and patch. With multi-select, the merge is activated when the dispatcher is transmitting. Users in the merged group automatically return to their original talkgroups at the end of the conversation. With patch, users remain in the patched group until the dispatcher manually ungroups them. Any user transmitting is heard by all radio users in the patch group.

- Roaming

Direct access roaming is the capability for a radio user to move about a large geographic area and be able to switch to different systems to meet his communications needs at different locations. It is a capability inherent in all Motorola trunked systems. The individual radio must be programmed to directly access all systems he wishes to roam to as well as be enabled on those systems by their system managers. When the user moves out of range of one system and into range of another, he must manually switch over to the new system by turning a selector knob or pressing a keypad (depending on the radio.) The ability to automatically switch systems is provided with System Search & Lock discussed in section IV. For more information on roaming applications see section V on interoperability.

System Design Flexibility

- Channel Capabilities and Expansion

The SMARTNET system is available in channel configurations of three to twenty channels. The required number of channels in the system is dependent on system loading. The system allows for unitary channel additions to meet the customer's need for expansion. Each time a channel is added to the system the central controller requires a software update to allow it to recognize and assign the new channel. No reprogramming of individual radio units is required. If the new channel(s) added exceed the 7 channel capacity of the existing receiver interface board(s) and transmitter interface board(s), additional board(s) will be required to expand the system.

- Message/Transmission Trunking

A SMARTNET system can be set up as message or transmission trunked. (Almost all customers choose message trunking.) With message trunking, a channel is assigned for the entire duration of each dispatch conversation. If a mobile or portable within the same talkgroup does not initiate another transmission within a prespecified repeater dropout time (beginning when the mobile or portable unkeys,) the channel will be reassigned. Repeater drop out time is adjustable up to 6 seconds via the System Manager Terminal. With transmission trunking, a radio channel is only assigned for the duration of a single transmission. At the end of each transmission, the radio unit sends a subaudible disconnect tone to inform the central controller that the channel is available for reassignment.

- Flexible Talkgroup Partitioning

Through software in a trunked radio system, there is a high degree of flexibility to partition communications into different talkgroups. A system may be set up so that some talkgroups may not even be aware that other groups exist on the system or that all talkgroups in a given fleet can communicate with one another. Some talkgroups or members of a talkgroup can have full feature capabilities, whereas other talkgroups or members may have limited capabilities. It is up to the customer to decide how he wants communication users to operate on his system.

Through the fleetmapping process, desired communication patterns are designed into the system. Privacy Plus, SMARTNET and SMARTNET SYSTEMS II differ in the combinations of talkgroups and individuals (size codes which can be allowed per fleet. Privacy Plus is the most restrictive with four different size codes available, providing from 16 to a maximum of 512 individuals per fleet; SMARTNET has 14 size codes available with a maximum of 4,096 individuals per fleet; and SMARTNET SYSTEMS II allows almost unlimited combinations of talkgroups and individuals up to 48,000 individuals. (Fleetmapping considerations were discussed in section I.)

- Expanded Fleetmapping (Type II)

The Type II fleetmap is a trunked system enhancement, transparent to the user, which is available only on SMARTNET SYSTEMS II. Type II will be inherent in all 900 MHz trunking equipment which is sold. Retrofit packages are available to upgrade existing 800MHz systems. Through a change in the addressing scheme used to reach individual radios, it allows a greater number (up to 48,000) of radios to operate on the system. It also adds flexibility to system design by expanding fleetmapping capabilities. With Type II, there is:

-One individual ID for each radio unit per system, up to 48,000
-No limit to the number of units per fleet
-No limit to the number of talkgroups per fleet
-Up to 4000 talkgroups per system in any combination of fleets and talk groups (2000 with Priority Monitor)
-No unusable unit ID's
-Reduced need for radio reprogramming due to fleet size changes

- Field Programming

Field programming is a tool which allows a radio system manager to change the programming of a radio, (change identity or enable/disable options in the radio.) Before an option can be enabled in the field, it must be enabled in at least one personality (code plug) of the radio. It allows customers the flexibility to change radio capabilities as communications needs change. Field programming is currently available for most Privacy Plus and SMARTNET radios. It is accomplished through a standalone field programmer or dial-up interface to the factory Trunking Code Management System (TCMS) database by a Motorola service shop employee.

EMERGENCY RESPONSE

- Emergency Alarm/Call

An emergency alarm is initiated from a portable or mobile by depressing a button which is solely devoted to emergencies. Once initiated, the radio unit sends a burst of data on the control channel to activate the emergency alarm. The dispatcher is immediately notified of the emergency status by an audible alert and visual display of the emergency caller's ID at one or more consoles, or a display of his alias on the SMARTNET Interface Management System (SIMS) user station or standalone Trunked ID Processor (TIP).

After the PTT is pressed, if a voice channel is available, it will be assigned immediately and the emergency call can proceed. Typically, the emergency call will take place in the talkgroup the user is on when he initiates the alarm. However, through specification on the trunking code management system, emergency calls can be directed to a dedicated talkgroup set up specifically to handle emergency traffic. This is typically applied in situations where no centralized dispatch operation exists. Similarly, if a user depresses the emergency button while a fleet call is selected, the emergency call will automatically take place on a preselected talkgroup.

Radios are usually programmed for both emergency alarm and call operation.

However, they can be programmed for emergency call or alarm only depending on customer requirements.

In the event of a busy, an emergency call will always be given the highest priority on a SMARTNET system or SMARTNET SYSTEMS II. Whether or not the system is busy, the emergency call is given an extended repeater hang time (up to 28 minutes.) This ensures the availability of the channel for the emergency. Two alternatives, ruthless preemption and top of the queue, are offered for handling emergency traffic during a busy period.

Top of the Queue:

With top of the queue, when an emergency call is requested from the radio and no channel is free, the emergency user is put first in the queue and all repeater hang times are set to zero. As soon as the first user on any channel dekeys, the emergency caller is granted that channel. The benefit of this approach is that there is no contention. The first available, clear channel is assigned and held by the emergency talkgroup. This is the preferred alternative.

Ruthless Preemption:

With this alternative, when an emergency call is requested and no channel is free, a repeater currently in use is assigned to the emergency calling unit. The central controller will select the repeater of the lowest preemption priority user on the system. At this point, the emergency caller must contend for the channel with another user until the non-emergency user dekeys. All others in the non-emergency talkgroup will drop back to the control channel; those listening in the emergency talkgroup will hear either or both transmissions until the non-emergency user dekeys. Once the non-emergency caller dekeys, the channel belongs to the emergency caller.

With ruthless preemption there will always be contention. The advantage of this alternative is immediate access.

Selective Calling

- Call Alert I

The Call Alert I option is available on all 800 MHz Privacy Plus and SMARTNET systems. It allows a dispatcher or radio user to selectively alert an individual so he knows that someone is trying to reach him. To initiate a Call Alert (C/A), the dispatcher or radio user switches the radio to the Call Alert mode and selects the individual to be called. (How this is done varies by radio.)

The alert is sent by pushing the PTT switch. The Call Alert produces an audible and visual alert (depending on the radio) on the receiving party's radio. The alert indicators stop when the Call Alert receiver presses his PTT. Receipt of the alert by the alerted radio unit is automatically acknowledged by indicators on the initiating caller's radio. All of this is accomplished through signalling over the control channel and does not affect voice channel efficiency.

Four different Call Alert I programming alternatives are available for mobile and portable radios: decode only (can receive but cannot initiate a Call Alert), single encode (can C/A one predetermined radio only), multiple encode (can C/A up to eight predetermined radios), unlimited (can C/A any other radio in a fleet which is C/A capable.) From a Centracom II console, the dispatcher can Call Alert any Call Alert enabled radios. Call Alerts can also be sent from SIMS or Trunked ID Processors.

System managers typically use different levels of Call Alert I capability to manage use of the feature.

For instance, one person per talkgroup (supervisory level) may be programmed with unlimited Call Alert I whereas others in the talkgroup are equipped with single encode. That way whenever a Call Alert is received, the user knows that it is his supervisor calling.

- Call Alert II

The benefit and operation of the Call Alert II option is similar to that of Call Alert I. The major difference between the two features is that the receiving unit of a Call Alert II will display and can store the calling party's ID. This is achieved through the transmission of a dual word message which identifies the caller and the receiver. This lends more power to the feature because it allows the receiver to know who is calling him. Therefore, if it is required, all users could be programmed with unlimited Call Alert, without creating confusion as to who sent the alert.

Call Alert II is available on 900 MHz Privacy Plus systems, and 800 and 900 MHz SMARTNET SYSTEMS II. The same programming alternatives (decode only, single encode, multi-encode and unlimited) are available for Call Alert II as for Call Alert I.

- Private Conversation (PC) I

In addition to talkgroup calls, a radio operator or dispatcher may selectively call another party to carry on a private conversation. To place a PC, the user must switch into the PC mode, select the individual he wants to speak with privately, and press his PTT. The caller will be able to reach an individual mobile or portable in his fleet as long as the called party is monitoring the control channel (not on a voice channel in another conversation,) no matter what talkgroup the receiving unit in. All necessary signalling is done on the control channel, eliminating any additional delays in call set up.

Once the Private Conversation is established, the two units will not hear any other normal traffic that occurs while the conversation is in progress, even if they return to the control channel during a pause. However, in the event that multiple callers are trying to reach the same supervisor for a Private Conversation, privacy will be disrupted. The calling parties will contend with one another until one drops out of the PC mode. A Private Conversation will be interrupted by a fleet wide or system call only after the transmitting party dekeys. Once a private conversation has been completed, radio operators must remove their radios from private mode in order to hear normal talkgroup traffic.

There are three alternatives for programming the Private Conversation I option in mobile and portable units: decode only (can receive but cannot initiate a Private Conversation), single encode (can PC one predetermined supervisory radio only), and multiple encode (can PC up to eight predetermined radios per personality.) This feature is typically set up so that supervisors and dispatchers have multiple encode PC and that all other users have single encode or decode only. In this way, the Private Conversation feature is oriented towards supervisory functions, and all others know who initiated the PC.

Private Conversation I is available on 800 MHz Privacy Plus and SMARTNET systems, although Private Conversation II is preferred on SMARTNET.

- Private Conversation (PC) II

The Private Conversation II option operates similarly to PC I. However, there are four notable differences to the user.

1) Private Conversations can cross fleet boundaries;

2) Radios can be programmed to PC an unlimited number of radios by ID;

3) With Enhanced Private Conversation, the user of a receiving unit can view the ID of the calling party (on display radios only.) This is achieved through a double word address sent over the control channel which includes the ID of the radio to be called as well as the ID of the radio initiating the call; and

4) With Private Conversation II, in no circumstance will users outside of the private parties hear the Private Conversation.

Programming alternatives for PC II include: decode only, single encode, multi-encode, unlimited and enhanced. Private Conversation II is available on all Privacy Plus, SMARTNET and SMARTNET SYSTEMS II systems, with the exception of Enhanced PC II which is only available on Type II systems.

- Universal ID

Universal ID is an optional feature on SMARTNET I systems and is standard on SMARTNET SYSTEMS II. One ID per system can be identified as the "universal ID." The radio will respond to or initiate any individual call (Call Alert, Private Conversation, interconnect, dynamic regrouping, or selective inhibit,) using the universal ID, even if the radio has multiple IDs on the system. The radio will respond to the currently selected ID as well as the universal ID.

Radio User Monitoring Capabilities

Motorola trunked radios do not need to scan the trunked channels to look for voice activity from multiple talkgroups. The radio only needs to monitor the control channel for activity of the groups desired.

- Trunked Talkgroup Scan

Trunked talkgroup scan is the least sophisticated of the trunked monitoring options. With this, a radio user can monitor a list of predetermined (programmed in the radio) talkgroups without priority placed on any of the talkgroups. Activity of these talkgroups will be monitored on a first in first out basis. If the user wants to join the conversation of a talkgroup he hears, he may manually switch over to that talkgroup on his radio, or the radio may be programmed for a short "talk back" time. If the user transmits during this time, he will join the talkgroup he just heard. In this version of scanning, if a conversation is in progress, it will not be interrupted by activity of one of the listed talkgroups.

Trunked talkgroup scan is available on all SMARTNET & SMARTNET SYSTEMS II systems, as an option on some radio models.

- Priority Monitor

With the priority monitor option, the user can monitor a list of five to eight talkgroups (depending on the radio) with one talkgroup given priority status. It can be ordered with a predetermined list of groups programmed into the radio (not changeable by the user) or with the capability of allowing the radio operator to select the priority groups he wants to monitor. The priority group can be preprogrammed or can be set to whatever group is currently selected when monitor is "turned on."

While in the monitoring mode, when a priority talkgroup is heard, the radio user will automatically have the ability to talk back to that group if he responds within a pre-set time, even if he was involved in another conversation with a non-priority group when the priority group was detected. However, if the user was talking he would not become aware of the priority conversation until he dekeyed his mic. A conversation with a priority group will not be interrupted by other monitoring activity. If a radio is involved in a secure voice call, it will not be interrupted by any monitoring activity, not even from a priority group.

Priority monitor is available as an option on all SMARTNET & SMARTNET SYSTEMS II systems. However, it cannot be used in size code A fleets/talkgroups.

Telephone Calls

The ability to place or receive phone calls on a radio unit is offered on all Motorola trunked radio systems. To provide SMARTNET users with interconnect capability requires equipment of both fixed end and individual radios. (For further detail, see the "Centralized Interconnect Product Digest," RO-6-08A) capacity is determined by the number of channels (1-20) which are equipped with interconnect capability. A shared service algorithm actively controls system interconnect parameters to maintain a preselected balance between dispatch and telephone call traffic.

Three types of phone calls can be implemented on a trunked radio system: individual mobile to landline, landline to individual mobile, and landline to talkgroup.

- Mobile to Landline

To initiate a mobile to landline call, the radio user presses his phone button, waits for a dial tone, and enters the number he wishes to call. If all interconnect channels are busy, the user will receive a busy signal and will be placed in a queue until an interconnect channel becomes available. A dial tone is heard when a channel has been assigned. All telephone calls are processed on a FIFO basis; priority levels are inoperative when in this mode. Once the call goes through, callers on a simplex radio (all but Privacy Plus or SMARTNET 1000) should instruct the land party to speak after they hear a short tone. This tone indicates that the radio has stopped transmitting and the radio user can now hear. The radio user must exit the phone mode in order to return to normal dispatch operation.

- Landline to Mobile

To place a landline to mobile call, the landline party dials a central telephone number. If a channel is available a tone prompts him to enter the four (six for SMARTNET II) digit number of the individual he wants to call. The radio user is made aware of the incoming phone call with telephone like ringing. He must switch into the telephone mode to respond to the call.

If all landlines into the radio system are busy, the caller will hear a normal telephone busy and must hang up and try again. If, after entering the land to mobile ID, there are no channels available, he will hear a fast ringing until an interconnect channel can be assigned. If the radio called is not available, not on the system or on a voice channel, the system will fast ring for up to 20 seconds. If after 20 seconds, the radio has not acknowledged its presence on the control channel, the call will be terminated.

- Landline to Talkgroup

A landline to talkgroup call is initiated the same way as a landline to mobile call. To call an entire talkgroup instead of just one individual, a seven digit number (9 + the talkgroup and individual ID) in SMARTNET I and 800 MHz Privacy Plus systems, or a four digit number in SMARTNET II and 900 MHz Privacy Plus are entered after the phone number. The central controller dispatches this call like any other talkgroup call and assigns a channel via the central controller. Talkgroup members hear and respond to the call as they would a normal talkgroup call.

-Rotary Dial

Where DTMF is unavailable, an optional interface can be provided to allow direct inward lines to be utilized. In this configuration, the landline to talkgroup calls cannot be placed unless DTMF overdial is available.

Interoperability/SIS I

SIS I is a set of SMARTNET features that can provide users the capability to communicate with those in other systems: SMARTNET and/or conventional (any band). These features are:

-Multiple System Access
-Console Patch
-System-to-System Interconnect
-Combination of the above

A description of these features as well as a discussion of SIS I candidates and application examples are presented in section V.

System Control and Monitoring Features

- Selective Radio Inhibit

Selective radio inhibit allows a dispatcher to deny an individual radio access to the trunked radio system over the air through commands sent via a standalone trunking terminal or SIMS. Once inhibited, the radio is inoperable (cannot transmit or receive) on a trunked system until the dispatcher restores it to operation. Once the inhibit command is given, the system begins an immediate, continuous five minute search looking for the radio to be inhibited. An acknowledgement is displayed at the terminal to show successful or unsuccessful inhibit searches. The inhibit command might be unsuccessful if the radio was turned off, out of range of the system, or in the Emergency mode (SMARTNET I only) during the five minute search time. The selective inhibit program would then offer the dispatcher the following set of alternatives. On SIMS, the dispatcher has the choice to cancel the search, initiate another high speed search or a monitor type search. The monitor search operates as a continuous background task, where SIMS monitors the control channel for any activity of the target unit. Detection of the unit triggers an automatic high speed search, starting with the ID detected and times out after 24 hours. If the high speed search is unsuccessful monitor is resumed.

On a standalone, if the initial high speed search is unsuccessful, the dispatcher can choose to abandon the search, decide later or select from the following search choices.

-High Speed- Up to one try per second for five minutes maximum, followed automatically with a medium speed search;

-Medium Speed- At least one try per each available ID every 15-20 minutes, up to one hour;

-Slow Speed- At least four tries per each available ID per day, up to one day;

-High, Medium, Slow sequence; or

-Monitor.

- Dynamic Regrouping

Individuals from different talkgroups may need to be brought together to communicate in the case of special situations. Regrouping is an important system control tool which allows the dispatcher or supervisor to change the talkgroup assignment of an individual radio to accommodate changes in communication needs.

The dispatcher or supervisor accomplishes regrouping by entering commands that are transmitted by SIMS or a standalone dynamic regrouping terminal to a radio via the control channel. Acknowledgement of completed regrouping tasks is displayed at the terminal. Indicators on individual radio units alert the user that he has been regrouped with four audible beeps. On display radios, talkgroup X will be displayed. From a radio with keypad activated talkgroup selection, a radio user can request to be cancelled from the regrouping mode by selecting talkgroup R and pressing his PTT.

Regrouping assignments can be initiated rapidly, but not instantaneously. Radios to be regrouped must be turned on, in range and listening only to the control channel (and not in the Emergency mode on SMARTNET I systems.) Regrouping is best suited for preplanned activities or occasional changes from normal routines. It is not intended for immediate emergency responses such as found in high speed chases or for rapid deployments on a per incident basis. In such cases, talkgroup merge (from the Centracom II console) is recommended.

- Storm Plans

As a function of dynamic regrouping, a dispatcher can construct a regrouping storm plan in advance via a trunking terminal (SIMS or standalone.) When activated, the plan would automatically regroup certain prespecified radios into other talkgroups. This tool is well suited for disaster preparedness (in response to plane crashes, floods, hurricanes or earthquakes,) VIP visits, parades, etc. It allows the dispatcher to store a regrouping plan for critical situations and to appropriately change communication patterns.

- Data Logging

The ability to view and print call processing activities is offered with all Motorola trunking systems. Data logging is used to troubleshoot system problems, to identify callers who misuse the system and for system planning. Tools available for this purpose include the datalogger and the SIMS logger/printer option.

The datalogger is a tool available with 800 MHz Privacy Plus and SMARTNET systems. It monitors and prints activity on the control channel as it occurs (but not real time.) For each call, the logger prints in a coded format: date and time initiated; fleet, talkgroup and individual identification (in hexadecimal or 6 digit ID); type of call, and channel assignment. SIMS can display and log similar information in plain English, using aliases for identification.

- Status/Message

This feature is available on all Motorola trunked systems. It allows a radio user to send a preprogrammed status update or message to the dispatcher. This feature is frequently used in the cement industry and for pick up and delivery businesses. All signalling for Status/Message is accomplished over the control channel and does not affect voice traffic.
Status/Message on a SIMS user station displays radio aliases in the appropriate Status/Message fields.

- PTT ID Display

Push to talk ID display is a SMARTNET (I & II) feature only. It allows a dispatcher to view the IDs of all callers as calls are being processed on the SIMS user station or a standalone Trunked ID Processor (TIP). When a call is

redundant site is activated by any condition that would trigger failsoft or by a power or antenna loss at the main site. An alarm and control system is employed to manage switching between the sites.

- Failsoft

Failsoft is a standard feature of all Motorola trunked radio systems. To ensure continued communications, the trunked system will go into the "failsoft mode" in the event of central controller failure, failure or disablement of all four control channels, or failure of all of the voice channels. A system will be in failsoft within 10 seconds after a failure has occurred, with the improved failsoft version. When in failsoft, radios will operate as they would on a conventional repeater system. A subaudible tone is continuously sent out by the system repeaters to let the radios know that the system is in failsoft. This also ensures that radios will not go into failsoft when they are out of range of the system. Radio users are made aware that the system has gone into failsoft by the automatic sounding of a low level, audible alert tone (sent by the repeaters) every 10 seconds.

Which channel(s) an individual radio user can talk on while in failsoft, is programmed into his radio. Depending on how many talkgroups there are on the system and how failsoft is set up, some talkgroup privacy may be lost.

It is standard to assign failsoft channels by fleet. Radios with multiple fleets will have a failsoft channel programmed for each fleet. The customer can optionally set up failsoft by talkgroup (a.k.a. failsoft by subfleet.) Each radio would then have an appropriate failsoft channel programmed for every talkgroup it has. When the radio user changes talkgroups while in the failsoft mode his radio would switch channels. Failsoft talkgroup assignments must be entered on TCMS for proper programming of the radios.

In planning for system failsoft assignments, the need to maintain talkgroup privacy should be balanced with the even distribution of traffic over all channels available. Failsoft assignments for specific radios can be changed through field programming, or can be temporarily changed for regrouped radios via SIMS or a standalone Dynamic Regrouping terminal.

- SMR Backup

An upgraded SMR with similar coverage can provide a back up system in the rare event of central controller failure, failure of a majority of channels on the system, power loss, or damage or loss of the antenna network. There are three alternatives for achieving switchover to the back up system: 1) radio users manually switch over to the SMR system; 2) radios are rendered active on the SMR system through access to the SMR System Manager Terminal, and radio users manually switchover to the SMR; and 3) radios switch over to the SMR system by utilizing the system search and lock feature of the radio (documented in section IV.)

- System Self Diagnostics

The central controller has the capability to diagnose system problems. It continually performs central controller integrity, repeater receiver interference and transmitter interface checks. The results of these checks can activate visual and audible alarms at the central controller site. Relay contacts on the back plane of the central controller are provided to implement these functions. The system manager terminal or SIMS System Manager Interface prints error messages as they are received via a central controller port. Optionally, every 24 hours, the following are checked: tone detectors on the receiver interface board (RIB); ROMS and EPROMS on all central controller boards; and memory and A/D circuitry on the inbound receiver board (IRB).

- Receiver Interference Shutdown

Receiver interference occurs when an unauthorized signal is received on a repeater. It can be caused when a mobile from another system with similar frequencies strays into range. In order to prevent a disruption of communications, the central controller will shut down a repeater when it detects an undesired carrier for longer than the specified time-out period.

- Transmitter Power Failure Shutdown

The central controller can detect a loss or decrease in transmitter output power. If the output of one of the repeaters drops below a threshold level (perceptible to system users,) the central controller will know not to assign that repeater and will send an error message to the system manager terminal. The central can also detect an excess of reverse power (typically due to an antenna fault.)

- Misdirected Radio Protection

A subaudible handshake has been designed into all Motorola trunked systems to prevent an individual from one talkgroup from gaining access to a channel that has already been assigned to another talkgroup. Once a channel has been assigned, the repeater continues to send an outbound stream of data which contains the unique ID of the talkgroup using the channel. If a radio unit from a different talkgroup were accidentally assigned the same channel, the radio would not recognize the outbound data and would automatically return to the control channel. The errant radio unit would have its audio muted and transmitter disabled for the fraction of time that it actually spent on the wrong channel. The radio unit would then go back to the control channel and find the correct voice channel assignment. With improved access systems, a short sound burst may be heard. For secure voice radios, proper code detect provides a similar operation.

- Continuous Assignment Updating

Continuous channel update is a feature of all Motorola trunked systems. It ensures that a radio just coming into service will be sent over to the appropriate voice channel to join the rest of his talkgroup if they are engaged in conversation. To achieve this, the control channel continuously transmits the channel assignments for talkgroups as long as they are using a channel. Assignment updates are sent serially and continuously.